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A Study of the Feasibility of Establishing Generic Environmental Test Parameters for all Consumer Products

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U. S. DEPARTMENT OF COMMERCE

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A study of the feasibility of developing test parameters for the behavior of consumer products under simulated or actual environmental conditions was conducted. This report constitutes a discussion of the results of this study. "Environmental," in this context, means those conditions to which the product might normally be exposed; for example, temperature, humidity, ultraviolet radiation, or weathering. These conditions may be static or cyclic, and may occur individually or in combination.

The initial purpose of this project was to establish a series of generic environmental test parameters applicable to all types of consumer products, which as a result of prolonged exposure to certain environmental conditions, would become hazardous.

A consumer product was assumed to be one normally used in an individual household. It was reasonable to assume that no individual product would be subjected to constant environmental conditions throughout its useful life, and that some products are intended to be used exclusively indoors, others exclusively outdoors, and others both outdoors and indoors.

Products which can become hazardous as a result of environmentally induced failure can be classified into two general categories, those which exhibit no change in parameters such as temperature, moisture content, etc. in use, and those which in normal use assume conditions not present during storage environments.

When this program was begun, it was realized that the proposed scope was too broad. It was obvious that certain limitations to the scope would be necessary if a reasonable approach to the problem of generic testing were to be achieved. Consequently, the test parameters selected for study were limited to the evaluation of products in the quiescent state, i.e., neglecting the fact that at various times during its useful life a product exposed to and preconditioned in a specific environment might be subjected to conditions that were totally irrelevant to the ambient conditions under consideration. For example, certain elements of a product might on becoming functional be rapidly subjected to temperatures hundreds of degrees above any normal environmental state. Thus, it was clear that any attempt to establish environmental test procedures involving all of the ramifications that would include all possible variants between product and environment would yield an unworkable number of test parameters. Consequently, the effects of normal use variants on the functional stability of a product were not included in this initial study.

Although the combined effects of functional use cycles and environmental conditions were excluded from this study, it was recognized that for a given product a hazard might not occur during exposure to various environmental storage conditions in the quiescent state. However, the problems involved in simply attempting to establish generic environ-

mental test parameters to cover all potentially hazardous products were enormous. Obviously the inclusion of functional cycles in a series of environmental test conditions would have to be based on the individual product and simulate as well as possible the conditions to which the product would be subjected in use.

In some cases environmental test procedures might be of little value unless associated with mechanical, physical, and chemical test procedures (exclusive of functional use cycles) in order to determine whether slow deterioration was occurring to the materials or components that would eventually render the product unsafe. Thus, tests of this type cannot be of a generic nature, but must be specifically selected to evaluate the materials and components in question. Some exceptions may occur. For example, a power tool associated with seasonal use may be subject to environmental extremes during long term non-use storage that would be basically irrelevant to the conditions encountered during use. In such cases tests to detect onset of safety deterioration might be expected to be used only in conjunction with cyclic test parameters typical of the environmental conditions encountered in use rather than those encountered during long term quiescent storage.

Of particular concern in this study were the types of failure modes that produce hazards due to adverse environmental conditions. The first phase of the study concerned an evaluation of injury surveillance data as a means of determining the types of environmental exposure test conditions that should be established. Data of this type may not indicate whether the injury was due to failure of the product, or the failure mode which produced the hazard. If the type of failure is described, or can be deduced, the cause of failure normally is not stated and is frequently unknown. Consequentially, it becomes difficult to determine the factual cause of failure, e.g. environmental deterioration, or mechanical failure due to normal wear or improper maintenance.

When a hazard producing failure occurs and results in an injury which is subsequently recorded in the surveillance data, it is possible to predict the approximate number of similar product related injuries that may occur in a specified period of time. However, there may be other instances of identical failures resulting from environmentally induced deterioration of the product, in which no injury occurs due to some fortuitous circumstance, such as the user's ability to recognize the inherent danger. It appears that under the present system of information retrieval, data on the latter type of potentially hazardous product failures would be available from the manufacturer or distributor only if appropriate records are maintained on returned items. However, data of this type might only be available for those products that were still under warranty, were repairable, or whose cost of repair was sufficiently low so that the owner would not discard the product.

The listing of consumer products contained in the complete NEISS Consumer Product Hazard Index was evaluated in order to determine those products which could be expected to deteriorate due to environmental exposure conditions, and capable of resulting in an injury producing failure. Many of these products were associated with the higher AFSI values reported in the Index. For convenience the individual products were grouped into pertinent general product categories. Some typical categories which include a majority of potentially hazardous products, divided into areas of primary intended use, are as follows:

Indoor Products	Outdoor Products
Small appliances	Sports and recreation equipment
Major appliances	Structures and materials
Communication equipment	Yard and garden tools and equipment
Entertainment appliances	
Children's furniture	
Home furnishings	
Structures and materials	
Workshop equipment	

It is obvious that the above products involve the use of a wide variety of materials and fabrication and assembly techniques.

A search of Federal and National Standards did not provide much assistance in the development of generic environmental test parameters that would be applicable to all of the product categories listed above. Most specifications and testing procedures are oriented towards basic materials and usually require test specimens of predetermined dimensions, and specific types of testing instrumentation. Frequently, the specimen configuration is not representative of that found in the end product, and the instrumentation may not be amenable to testing the entire product. Assuming that most products are composites and assemblies it is possible that if a failure mode can be associated with a specific component or sub-assembly then test procedures for these specific items, rather than the complete product might be developed. When appropriate basic materials standards are available they may be used to specify the requirements for the material used in such a component. On the basis of the small amount of data commonly available on product related injuries, it seems reasonable to suspect that many hazard producing failures may be due primarily to some inherent fault in the product such as poor design or selection of an inadequate material. Although in the latter case, materials standards may serve as the basis for selection of a more appropriate material, this often results in an increase in cost of the product.

The evaluation of some products may require only the use of a relatively simple combination of environmental parameters, such as temperature and humidity cycling at simulated indoor conditions. Products intended for infrequent outdoor use may have to be evaluated for resistance to greater temperature extremes, sunlight, rain, wind

erosion, industrial fumes, etc. It is obvious that in most cases these additional test parameters would only add to the complexity of the testing problems. Another problem arises for those products which while functioning normally undergo a transformation that drastically alters the conditions induced by the environment; for example, a rapid rise in temperature of the product. Probably some products of this type should be subjected to dual test procedure, one in which it remains quiescent, and one in which it would become functional at specified intervals and conditions. Regardless of the types of environmental parameters to which a product is subjected, if the results are to be of value, the product undoubtedly will need to be subjected to one or more mechanical, physical or chemical tests in order to determine whether slow deterioration of properties is occurring that would result in an unsafe product. Such limitations would necessarily require each product or product design to be evaluated on its own merit regarding its resistance to failure. In order to be of significance such an evaluation must take into consideration the intended use, probable location and duration of use, the types of materials used, and the assembly techniques used. The simulated environmental test program could be developed for obtaining a reasonable degree of certainty that failure of the product would not result in a potentially injurious hazard. However, it must be recognized that many simulated test conditions do not exactly match those encountered in normal service. Consequently in developing a test procedure it is reasonable to increase the severity of the tests.

A thorough study of the types of failure occurring in a given product would provide information that would be extremely useful to the design and materials engineer, and for developing means that would lead to the elimination of a recurrence of the failure. A study of the degree of usage, distribution of usage, and the relationship of these factors to the ratio of injuries occurring could be the basis for, and act as an aid in, the selection of the most appropriate environmental test parameters.

In conducting environmental tests in the laboratory it is generally considered wise, if practical, to exceed the conditions to which a product might normally be expected to be exposed during its service life. By using limited increases in severity in laboratory testing, particularly when performing cyclic tests, potential failure modes due to the selection of materials, design criteria, etc., may be more readily identifiable. Nevertheless, environmental laboratory tests often do not simulate all of the parameters to which a product may be exposed. Therefore, increasing the severity of tests which do simulate environmental conditions may offset the inability to duplicate certain conditions. For example, no reference could be found for a standard laboratory test procedure that simulated the effects of industrial fumes and airborne particulate matter, which frequently may result in an increased rate of deterioration particularly in conjunction with other weathering factors such as sunlight and rain.

When consideration is given to the wide variety of materials and types of construction used in various products, it is evident that the usual standardized test procedures are inadequate. These, which are basically concerned with a single material or construction, would rarely predict a product malfunction due to basic differences in the response of dissimilar materials to various environmental situations.

A standard test procedure intended primarily for use in the evaluation of a single material or a simple composite may require some modification when adapted to the testing of an end product, if the standard procedure involves the subjecting of the product to conditions that are abnormal to its intended use. Thus, the effect of elevated temperature on a fabricated component may be more severe than it would be on a carefully prepared laboratory test specimen. As an example, a molded thermoplastic material may be unaffected by test temperatures up to 70-75°C (158-167°F), but if exposed to a temperature of 85°C (185°F) in order to accelerate the effects of temperature, might rapidly distort and result in a hazardous condition. Thermally induced distortion is usually related to the temperature at which the plastic was cooled after molding and may occur at a much lower temperature than that of the distortion temperature required for a laboratory prepared test specimen made in conformance with a basic standard specification. With some materials accelerated cycling between two different relative humidities may not approximate actual exposure conditions due to the inability of the material to equilibrate rapidly at each extreme of the test cycle. Materials which are hydrophobic by nature may require several days, or more, depending upon thickness and area of exposure, for the moisture content to become fully equilibrated with the surrounding atmosphere.

One proposed criterion for the study was the establishment of environmental parameters which simulate those encountered in geographic regions of the country. When the possibility of developing such environmental test parameters was considered, based primarily on atmospheric conditions, i.e., daily mean temperatures, daily high and low temperatures, variations of relative humidity, average monthly high and low temperatures, hours of sunlight and rainfall, it appeared that very few products would fall solely into a regional category. In evaluating mean temperature data of various areas of the country, for example, there did not appear to be much variation between northern and southern latitudes, with the possible exception of Alaska. It is well known that the number of days and the portions of each day in which the maximum and minimum extremes of temperature occur may vary considerably from one geographic location to another. Nevertheless, many products are distributed on a nationwide basis. In some regions, topographical variations may cause as great a difference in some climatological conditions, as those occurring over large intraregional distances. Therefore, it appeared that an approach based on regional environmental conditions would lead to unwieldy test parameters. Consequently, it was felt that generic types of environmental test conditions

could be adapted realistically to a given type of product regardless of geographic location of use. However, regionality could result in a variable ratio of product to population. With these points in mind, it seems that a reasonable approach to environmental cycling tests would, as in the case of variations in temperature and relative humidity, involve a number of cycles between high and ambient temperature at various relative humidities, followed by similar cycling between ambient and low temperatures, to separately simulate exposure to summer and winter conditions, respectively. This would minimize thermal shock effects such as might occur in alternate cycles of high and low temperatures, but to which the product might never be exposed in actual use. However, the technique of rapid cycling between high and low temperatures, for the express purpose of inducing thermal shock, may be advantageous with regard to accelerated test procedures: an example is the testing of products consisting of composites in which various components consist of or are fastened together by materials having distinct differences in their coefficients of thermal expansion.

An example of the problems that can occur in attempting to establish generic environmental test conditions is as follows. A product intended for indoor use only might only need to be subjected to cycling tests between two specified temperatures, for example, 25°C (77°F) and 60°C (140°F), while being simultaneously subjected to various relative humidities, for example, 20, 50, or 90%. There are at least nine different combinations between these two temperature extremes and three relative humidity percentages depending on whether the R.H. remains constant, increases or decreases with rise in temperature.

Artificial weathering devices may vary in their ability to simulate or accelerate degradation compared to how it would occur under natural weathering conditions. Frequently the major determinant governing the effect of these devices is directly associated with the composition of the material undergoing test. Variations may also occur as a result of the availability of a choice of the light source (carbon-arc, Xenon-arc) and the test cycle used, e.g., light only, light plus light/water spray, or either of these in combination with a dark period.

Similar choices of test conditions occur in the simulation of other types of environmental conditions. Usually the most appropriate test conditions are determined by the type of material being investigated.

When the addition of an operating cycle of a product results in a change in its conditioned state at any part of a test cycle, the complexities involved in attempting to establish a set of environmental test parameters capable of use on all products susceptible to hazard producing failures is readily obvious.

In conclusion it is apparent that no single set of generic environmental conditions would provide a completely adequate means of assessing their effects on all types of consumer products subjected to environmentally induced, potentially hazard producing failures. Nor does it appear that limiting a proposed set of conditions to a specific region would in any way decrease the complexity of such testing procedures.

It may be possible to establish some broad general limits for parameters such as temperature, relative humidity, ultraviolet exposure, etc., which might be applicable as a first approximation in establishing design criteria for a specific product.

However, it seems that it will be essential to limit environmental testing to only those parameters appropriate to a specific product, or to a limited series of comparable products normally exposed to similar environmental conditions. This could result in the need for a comprehensive analysis of the potential failure modes of each type of product, followed by a selection of arbitrary parameters most likely to induce failure during the expected service lifetime of the product. Such parameters would necessarily have to be based on both the materials used and the methods of construction or assembly used to produce the end product.

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A study was conducted to determine the feasibility of establishing a set of generic environmental test parameters that would be applicable to all types of consumer products, with a potential for developing injury producing hazards as a result of environmentally induced failure. It was concluded that this approach is not a practical one. It is apparent that the safeness of a product or type of product should be determined on the basis of simulated environmental tests appropriate to its specific end use.

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